8 FIBERS - NATURAL

8.1 Introduction to Natural Fibers

8.1.1 Objectives

Through completion of this module the trainee will develop the theoretical knowledge to be conversant in:

- The history and use of natural fibers;
- Fiber terminology; and,
- The origin of common natural fibers.

8.1.2 Required Readings

8.1.2.1 David, Shantha K. and Pailthorpe, "Classification of Textile Fibres: Production, Structure and Properties", Robertson, J. and Grieve, M., eds., Forensic Examination of Fibres, 2nd ed., Taylor & Francis, 1999, pp. 1-31.

8.1.3 Questions

The trainee will provide written answers to the following questions:

- Name three categories of natural fibers and discuss each category.
- What are the most common plant fibers encountered in casework?
- What are the two most common animal fibers encountered in casework?

8.1.4 Evaluation

8.1.4.1 The trainer will review the written answers to the questions with the trainee.

8.1.4.2 The trainer and the trainee will review and discuss the pertinent points of each of the required readings.

8.1.4.3 The trainee will be quizzed orally upon the subject matter.

8.2 Recognition, Collection, Packaging and Controls

8.2.1 Objectives

Through completion of this module the trainee will have developed and demonstrated theoretical knowledge and/or practical skills to:

- Describe to an investigator the proper way to collect fiber evidence;
- Recommend proper packaging for fiber evidence; and,
- Detail the proper controls that are to be taken and why.

8.2.2 Required Readings

8.2.2.1 Biermann, Thomas W., "Fibre Finder Systems", Robertson, J. and Grieve, M., Forensic Examination of Fibres, 2nd ed., Taylor & Francis, 1999, pp. 135-152.

8.2.2.2 Robertson, James and Roux, Claude, "Transfer, Persistance and Recovery of Fibres", Robertson, J. and Grieve, M., Forensic Examination of Fibres, 2nd ed., Taylor & Francis, 1999, pp. 89-100.

8.2.2.3 Springer, Faye, "Collection of Fibre Evidence from Crime Scenes", Robertson, J. and Grieve, M., Forensic Examination of Fibres, 2nd ed., Taylor & Francis, 1999, pp. 101-115.

8.2.2.4 Virginia Division of Forensic Science Evidence Handling Guide.

8.2.3 Questions

- Describe three ways of collecting foreign fibers from clothing.
- Describe the advantages and disadvantages of each the three techniques.
- What type of textile material has good fiber shedding characteristics?
- What type of textile material has good fiber retention properties?
- Why are control fiber samples important?
- Do natural fibers shed easily?
- How is evidence handled in terms of contamination prevention?

8.2.4 Practical Exercises

8.4.1 Demonstrate the druggist or paper fold to the trainer.

8.4.2 Demonstrate how to use post-it-notes to collect loose fibers.

8.4.3 Explain to the trainer the information given to an officer over the phone if asked what evidence should be collected in an abduction case where the victim was transported in the suspect's car.

8.4.4 Explain to the trainer the information given to an officer regarding evidence to be collected in a rape case where there was contact between the victim and suspect.

8.4.5 Explain to the trainer the information given to an officer regarding evidence to be collected in a breaking and entering case where loose fibers can be seen on the edges of the broken window.

8.2.5 Evaluation

8.2.5.1 The trainer will review the written answers to the questions with the trainee.

8.2.5.2 The trainer and the trainee will review and discuss the pertinent points of each of the required readings.

8.2.5.3 Review of practical exercises.

8.3 Stereomicroscopic Evaluation of Fibers (and Fabric)

8.3.1 Objectives

Through completion of this module the trainee will have developed and demonstrated theoretical knowledge and/or practical skills to:

- Use a stereomicroscope properly;
- Work with extremely small samples;
- Identify fibers as natural fibers versus synthetic fibers;
- Discern colors accurately, including pastels;
- Discern unique features, like scale patterns, root shapes on animal hair samples, spiral elements present in sisal and others;
- Determine the twist of yarns;
- Discern blends of fibers in yarns;
- Recognize and recover fibers from debris, clothing and from tools;

- Describe the weave and knit patterns of a textile/fabric;
- Make cross-sections of fibers;
- Perform the dry twist test; and,
- Prepare and view scale patterns.

8.3.2 Required Readings

8.3.2.1 Carroll, G. R., "Forensic fibre microscopy", Robertson, J., ed., Forensic Examination of Fibres, 1st ed., Ellis Horwood Ltd., London, 1992, pp. 101-102.

8.3.2.2 David, S.K., Pailthorpe, M.T., "Classifications of Textile Fibres: Production, Structure, and Properties", Robertson, J. and Grieve, M., eds., Forensic Examination of Fibres, 2nd ed., Taylor & Francis, London, 1999, pp. 1-31.

8.3.2.3 Gaudette, B., "The Forensic Aspect of Textile Fiber Examination", Saferstein, R., ed., Forensic Science Handbook, Vol. II, Prentice-Hall, Inc., Englewood Cliffs, NJ, 1988, pp. 209-214 and 239-241.

8.3.2.4 Nielsen, M. R., "Common Natural Fibers", Handout, Bureau of Criminal Apprehension, St. Paul, MN, October 1998.

8.3.2.5 Palenik, S. "Microscopical Examination of fibres", Robertson, J. and Grieve, M., eds., Forensic Examination of Fibres, 2nd ed., Taylor & Francis, London, 1999, pp. 156-159.

8.3.2.6 Robertson, J., "Protocols for Fibre Examination and Initial Preparation", Robertson, J. and Grieve, M., eds., Forensic Examination of Fibres, 2nd ed., Taylor & Francis, London, 1999, pp. 116-134.

8.3.3 Questions

The trainee will provide written answers to the following questions:

- What characteristics can be observed from a microscopic examination of natural fibers?
- How does one compare the colors of known and questioned fibers under the stereomicroscope?
- What influence does fiber diameter have at this point in the examination?
- What other fiber characteristics can play a major role in the stereomicroscopic "search" process?
- How does one ensure that the fiber samples will not be contaminated?
- What characteristics cause fibers to be eliminated at this stage?
- What material can be used to make scale casts?

8.3.4 Practical Exercises

8.3.4.1 The trainer will discuss with the trainee how to take appropriate notes, how to properly use worksheets and what abbreviations are in standard use for fiber analysis.

8.3.4.2 At the stereomicroscope, the trainer will demonstrate/discuss color, luster, diameter (coarse/medium/fine) and any other applicable observed characteristics of different fiber samples (animal and plant). Demonstration by the trainer will include manipulation of single fibers to remove and mount them in an applicable mounting medium.

8.3.4.3 The trainer will provide several natural fiber samples that are large enough to allow the trainee to familiarize themselves with the manipulation of fibers using the stereomicroscope.

8.3.4.4 The trainee will use the 8.3.4.2 fibers and make cross-sections using different techniques.

8.3.4.5 The trainee will be provided with a minimum of six animal hair samples from which they will make scale casts. Record/sketch observations of the scale patterns under the stereomicroscope.

8.3.4.6 The trainer will demonstrate the dry twist test. The trainee will perform the dry twist test on a minimum of six plant fibers provided by the trainer. Record observations.

8.3.4.7 The trainer will provide a "debris" sample with a known number of fibers. The trainee will search the debris and report the number and color of the fibers recovered.

8.3.4.8 The trainer will provide the trainee with an article of clothing containing foreign fibers for the trainee to recover the fibers.

8.3.4.9 The trainer will provide a variety of fibers and mounting media to the trainee. The trainee will mount the same fibers in each of the mounting media. The trainee should be able to discuss the advantages and disadvantages of the different mounting media.

8.3.5 Evaluation

8.3.5.1 The trainer will review the written answers to the questions with the trainee.

8.3.5.2 The trainer and the trainee will review and discuss the pertinent points of each of the required readings.

8.3.5.3 Review of practical exercises.

8.4 Microsolubility and Microchemical Testing

8.4.1 Objectives

Through completion of this module the trainee will have developed and demonstrated theoretical knowledge and/or practical skills to:

- Safely prepare microchemical test reagents; and
- Correctly describe the color reactions and/or the solubility of fibers when subjected to different chemicals and reagents.

8.4.2 Required Readings

8.4.2.1 The Textile Institute, Identification of Textile Materials, 7th ed., Grosvenor Press, Portsmouth, NJ, 1975, pp. 28-29 and 181-187.

8.4.3 Questions

The trainee will provide written answers to the following questions:

- Name three reagents used in microchemical test?
- What is LeRosen used for in microchemical testing of fibers?
- Should two fibers that have different reactions to any chemical or reagent be eliminated or should more testing be done on the fibers?

8.4.4 Practical Exercises

8.4.4.1 The trainee will assemble the necessary reagents. The trainee will become familiar with the requirements and will perform appropriate QC checks.

8.4.4.2 The trainer will provide the trainee with known samples of dyed natural fibers including those visually close in color. These knowns will be tested using 75% Sulfuric Acid, concentrated nitric acid, concentrated hydrochloric acid and LeRosen. The results will be recorded on the fiber microchemical worksheet.

8.4.4.3 The trainer will provide the trainee with a "K" and a "Q" fiber sample. The trainee will examine the fibers and characterize as to colors, solubility, microchemical reactions class and determine whether or not they match. Record results on fiber microchemical worksheets.

8.4.5 Evaluation

8.4.5.1 The trainer will review the written answers to the questions with the trainee.

8.4.5.2 The trainer and the trainee will review and discuss the pertinent points of each of the required readings.

8.4.5.3 Review of practical exercises.

8.5 Fluorescence

8.5.1 Objectives

Through completion of this module the trainee will have developed and demonstrated theoretical knowledge and/or practical skills to:

- Operate the fluorescence microscope properly;
- Discern and describe fluorescence colors accurately;
- Communicate the principles of fluorescence microscopy; and,
- Communicate the difference between the fluorescence cubes.

8.5.2 Required Readings

8.5.2.1 Rost, F.W.D., Fluorescence microscopy, Vol. 1, Cambridge University Press, Great Britain, 1996, pp. 1-63 and 104-128.

8.5.3 Questions

The trainee will provide written answers to the following questions:

- What is fluorescence?
- Is fluorescence microscopy a sensible technique to use in natural fiber comparisons?
- Is fluorescence microscopy suitable for undyed natural fibers?
- Is a difference in fluorescent properties a basis for elimination of two fiber samples?
- What are the most suitable mounting media for fluorescence microscopy and why?

8.5.4 Practical Exercises

8.5.4.1 The trainer will provide the trainee with a minimum of ten fibers for the determination of their fluorescent properties. The fibers should include dyed and non-dyed samples, as well as animal and plant fibers. All four fluorescent cubes will be used and the results recorded using the fluorescence worksheet.

8.5.4.2 The trainer will issue the trainee a minimum of five sets of K & Q fiber samples for comparison of their fluorescence properties. All four fluorescent cubes will be used and the results recorded using the fluorescence worksheet.

8.5.4.2 The trainee will mount fibers from the same source in Xylene substitute, glycerin, Permount, Pro-Texx and Norland Optical adhesive. All four fluorescent cubes will be used and the results recorded using the fluorescence worksheet.

8.5.5 Evaluation

8.5.5.1 The trainer will review the written answers to the questions with the trainee.

8.5.5.2 The trainer and the trainee will review and discuss the pertinent points of each of the required readings.

8.5.5.3 Review of practical exercises.

8.6 Polarized Light Microscopy (PLM)

8.6.1 Objectives

Through completion of this module the trainee will have developed and demonstrated theoretical knowledge and/or practical skills to:

- Use the polarized light microscope properly;
- Communicate the principle of polarized light;
- Set up Kohler illumination on the polarized light microscope;
- Determine the optical properties of fibers;
- Determine the "optical cross-section" of fibers;
- Recognize unique features and/or characteristics in fibers;
- Determine whether a fiber is pigmented or dyed;
- Determine the diameter of a fiber;
- Identify most common plant fibers; and,
- Identify animal hair fibers as such.

8.6.2 Required Readings

8.6.2.1 McCrone, Walter C., et.al., Polarized Light Microscopy, Ann Arbor Science Publishers, Inc., Ann Arbor, MI, 1978.

8.6.2.2 Palenik, Samuel J., "Microscopical Examination of Fibres", Robertson, J. and Grieve, M., Forensic Examination of Fibers, 2nd ed., Taylor & Francis, 1999, pp. 153-177.

8.6.2.3 Appleyard, H.M., Guide To The Identification of Animal Fibers; Wool Industries Research Association: Leeds, England 1960.

8.6.2.4 Cook, Gordon, Handbook of Textile Fibers, Fifth Edition 1984.

8.6.2.5 Hicks, John, Microscopy of Hair, F.B.I., Issue 2, January 1977.

8.6.2.6 Introduction to Hairs and Fibers Training Course Materials, F.B.I., March 1998.

8.6.2.7 Palenik, S. and Fitzsimons, Forensic Microscopy, "Fiber Cross-Sections: Part II", *Microscope*, 1990 (38) pp. 313-320.

8.6.3 Questions

The trainee will provide written answers to the following questions:

- Define polarized light.
- Describe the steps of setting up Kohler illumination.
- How are interference colors produced?
- Define refractive index.
- Define birefringence.
- Define extinction.
- Define sign of elongation.
- Define pleochroism/dichroism.
- Define compensation.
- Can natural fibers be identified by PLM alone?

8.6.4 Practical Exercises

8.6.4.1 The trainer will demonstrate to the trainee setting up Köhler illumination on the polarized light microscope, which will include centering the objectives.

8.6.4.2 After a period of practice, the trainee will demonstrate setting up Köhler illumination on the polarized light microscope, which will include centering the objectives.

8.6.4.3 The trainer will issue the trainee a known set of natural plant fibers, including cotton, kapok, flax, jute, hemp, ramie, sisal, abaca and coir. The trainee will determine the physical and optical properties of these fibers and record the results on a fiber worksheet.

8.6.4.4 The trainer will issue the trainee a set of unknown natural plant fibers. The trainee will determine the physical and optical properties of each fiber and identify the fibers.

8.6.4.5 The trainer will issue the trainee a known set of natural animal fibers (hair and silk) including wool, cashmere, mohair, camel, alpaca, llama, vicuna, rabbit, horse, silk (Bombay Mon) and silk (Tussah). The trainee will determine the physical and optical properties of the fibers. The trainee will record the results on the fiber worksheet.

8.6.4.6 The trainer will issue the trainee a set of unknown animal hair fibers. The trainee will determine the physical and optical properties of each animal hair fiber and identify the animal hair fibers.

8.6.5 Evaluation

8.6.5.1 The trainer will review the written answers to the questions with the trainee.

8.6.5.2 The trainer and the trainee will review and discuss the pertinent points of each of the required readings.

8.6.5.3 Review of practical exercises.

8.7 Microspectrophotometry (MSP)

8.7.1 Objectives

Through completion of this module the trainee will have developed and demonstrated theoretical knowledge and/or practical skills to:

- Communicate the principles of microspectrophotometry;
- Operate the microspectrophotometer in transmittance and reflectance modes;
- Obtain transmittance spectra of fibers in the visible region;
- Discuss the effect of fiber cross-section on the reproducibility of the results; and

- Discuss the effect of focus on the reproducibility of the results.

8.7.2 Required Readings

8.7.2.1 Gaudette, Barry D., "The Forensic Aspects of Textile Fiber Examination", Saferstein, R., Forensic Science Handbook, Vol. 2, Prentice Hall, Englewood Cliffs, NJ, 1988, pp. 245-248.

8.7.2.6 Adolf, Franz-Peter and Dunlop, James, "Microspectrophotometry/Colour Measurement", Robertson J. and Grieve M., ed(s), Forensic Examination of Fibers, pp 251-289.

8.7.2.7 Grieve M., Dunlop J., Haddock P., An Investigation of Known Blue, Red, and Black Dyes Used in the Coloration of Cotton Fibers, Journal of Forensic Science, Vol 35 (2) March 1990, pp. 301-315.

8.7.3 Questions

The trainee will provide written answers to the following questions:

- Define microspectrophotometry.
- Define metamerism.
- What is necessary to perform MSP in the UV region? Can the S.E.E. instrument do this?
- Is a difference in spectral curves a basis for elimination of K and Q fibers?
- Describe how to overcome heterogeneity in a sample when analyzing via MSP?
- How many sample scans should be performed on a single fiber?
- Are lighter colors or darker colors better for MSP purposes?
- Is MSP a good technique for undyed natural fibers?
- Discuss the expected results from near colorless fibers and near opaque fibers.
- How can weathering affect a fiber's color?
- Would MSP ever be done to compare a pink fiber to a red fiber? Why or why not?

8.7.4 Practical Exercises

8.7.4.1 The trainee will complete the microspectrophotometry section of the training manual.

8.7.4.2 The trainer will issue the trainee a dyed natural fiber and an undyed natural fiber. The trainee will obtain 10 transmittance spectra along the length of each fiber. The trainee will evaluate the reproducibility of the spectra and give reasons for possible differences.

8.7.5 Evaluation

8.7.5.1 The trainer will review the written answers to the questions with the trainee.

8.7.5.2 The trainer and the trainee will review and discuss the pertinent points of each of the required readings.

8.7.5.2 Review of practical exercises.

8.8 Supervised Casework

The trainee will work at least five forensic cases as a technician for a qualified fiber examiner. The trainer should ensure as much variety in the casework as is practicable.

8.9 Forensic Significance of Fibers

The trainer and the trainee will discuss the interpretation of fiber evidence and its relevance and weight in reports and in testimony. Discussions will include probabilities versus possibilities.

8.9.1 Required Readings

8.9.1.1 Champod, Christophe and Taroni, Franco, "The Bayesian Approach", Robertson J. and Grieve M., ed(s), Forensic Examination of Fibers, pp 379-398.

8.9.1.2 Grieve, Michael, "13.1 Influential Factors, Quality Assurance, Report Writing and Case Examples", Robertson J. and Grieve M., ed(s), Forensic Examination of Fibers, pp 363.

8.9.1.3 Pounds, C.A. and Smalldon, K.W., "The Transfer of Fibres Between Clothing Materials During Simulated Contacts and Their Persistence During Wear: Part I – Fibre Transference", *Journal of Forensic Sciences*, 1975, 15, pp. 17-27.

8.9.1.4 Pounds, C.A. and Smalldon, K.W., "The Transfer of Fibres Between Clothing Materials During Simulated Contacts and Their Persistence During Wear: Part II – Fibre Persistence", *Journal of Forensic Sciences*, 1975,15, pp. 29-36.

8.9.1.5 Pounds, C.A. and Smalldon, K.W., "The Transfer of Fibres Between Clothing Materials During Simulated Contacts and Their Persistence During Wear: Part III – A Preliminary Investigation of the Mechanisms Involved", *Journal of Forensic Sciences*, 1975, 15, pp. 197-207.

8.9.1.6 Webb-Salter, Martin and Wiggins, Kenneth G., "13.2 Aids to Interpretation", Robertson J. and Grieve M., ed(s), Forensic Examination of Fibers, pp 364-378.

8.10 Report Writing

The trainer will review and discuss with the trainee the standard report wording in Section 4.6 of the Trace Evidence Standard Operating Procedures.

The trainer will provide ten cases previously examined by other qualified fiber examiners for the trainee to review and discuss with the trainer.

The trainee will draft report wording as a part of the analysis of their training sets as well as when performing supervised casework.

Report writing will be evaluated throughout the training period by the trainer.

8.11 Fiber Presentation and Oral Examination

The trainee will prepare a presentation of approximately 20-30 minutes in length which they will present to a group consisting of qualified fiber examiners, the QA Coordinator, as available, and any Director that chooses to attend. The presentation may cover either: the forensic examination of natural fibers or a current topic that has been approved by the Section Chief that is of interest to the forensic fiber community.

The trainee will field questions regarding their presentation topic as well as questions related to any/all aspects of their fiber training.

8.12 Competency Evaluation and Mock Trial

8.12.1 As the trainee progresses through fiber training, they will begin to process training sets as they would for casework to include drafting a Certificate of Analysis. There will be a minimum of three of these "case" files completed prior to issuance of the final competency test.

8.12.2 Using one or all of the "cases" from 8.12.1, the trainee will undergo a series of "mini-mock trial" practice sessions with qualified examiners from the Trace Evidence Section. It may be useful to include practice sessions with examiners from Sections other than Trace Evidence.

8.12.3 The trainee will be provided with a final competency test for analysis. This test will mimic actual casework to the maximum extent possible and will include at least two matching fiber samples, one fiber sample that cannot be associated with the others and one identification of a fiber. Additionally, this test will include at least one positive fracture match for those trainees who have not previously completed documented fracture match training.

The trainee will analyze the final competency test samples and issue a Certificate of Analysis based upon their findings. The trainee will be called upon to defend their results via testimony in a formal mock trial setting. The mock trial will typically be scheduled about two weeks after the fiber presentation and oral examination.

8.12.4 The trainer and the trainee will review the mock trial video tape in a timely fashion.

8.13 Reading List

8.13.1 Appleyard, H.M., Guide To The Identification of Animal Fibers; Wool Industries Research Association: Leeds, England 1960.

8.13.2 Cook, Gordon, Handbook of Textile Fibers, Fifth Edition 1984.

8.13.3 Grieve M., Dunlop J., Haddock P., An Investigation of Known Blue, Red, and Black Dyes Used in the Coloration of Cotton Fibers, *Journal of Forensic Sciences*, Vol. 35 (2) March 1990, pp. 301-315.

8.13.4 Hicks, John, Microscopy of Hair, F.B.I. Issue 2, January 1977.

8.13.5 Introduction to Hairs and Fibers Training Course Materials, F.B.I., March 1998.

8.13.6 McCrone, Walter C., et.al., Polarized Light Microscopy, Ann Arbor Science Publishers, Inc., Ann Arbor, MI, 1978.

8.13.7 Nielsen, M. R., "Common Natural Fibers", Handout, Bureau of Criminal Apprehension, St. Paul, MN, October 1998.

8.13.8 Palenik, S. and Fitzsimons, Forensic Microscopy, Fiber Cross-Sections: Part II, *Microscope*, 1990 (38) pp. 313-320.

8.13.9 Pounds, C.A. and Smalldon, K.W., "The Transfer of Fibres Between Clothing Materials During Simulated Contacts and Their Persistence During Wear: Part I – Fibre Transference", *Journal of Forensic Sciences*, Vol. 15, 1975, pp. 17-27.

8.13.10 Pounds, C.A. and Smalldon, K.W., "The Transfer of Fibres Between Clothing Materials During Simulated Contacts and Their Persistence During Wear: Part II – Fibre Persistence", *Journal of Forensic Sciences*, Vol. 15, 1975, pp. 29-36.

8.13.11 Pounds, C.A. and Smalldon, K.W., "The Transfer of Fibres Between Clothing Materials During Simulated Contacts and Their Persistence During Wear: Part III – A Preliminary Investigation of the Mechanisms Involved", *Journal of Forensic Sciences*, Vol. 15, 1975, pp. 197-207.

8.13.12 Robertson, J., ed., Forensic Examination of Fibres, 1st ed., Ellis Horwood Ltd., London, 1992

8.13.13 Robertson, J and Grieve, M., Forensic Examination of Fibers, 2nd ed., Taylor & Francis, 1999.

8.13.14 Rost, F.W.D., Fluorescence microscopy, Vol. 1, Cambridge University Press, Great Britain, 1996.

8.13.15 Roven, "A Comparison & Evaluation of Techniques for Identification of Synthetic Fibers", *Journal of Forensic Sciences*, Volume 15, Number 3, pp. 410-432.

8.13.16 Saferstein, Richard, ed., Forensic Science Handbook, 2nd. ed., Prentice-Hall, Inc., Englewood Cliffs, NJ, 1988.

8.13.17 The Textile Institute, Identification of Textile Materials, 7th ed., Grosvenor Press, Portsmouth, NJ, 1975.

8.13.18 Virginia Division of Forensic Science Evidence Handling Guide.

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